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Mobile Cleaning Equipment for Recreation Facilities

U.S. DEPARTMENT of AGRICULTURE FOREST SERVICE
EQUIPMENT DEVELOPMENT CENTER SAN DIMAS, CALIFORNIA

NOVEMBER 1971

Equipment Development and Test Report 2300-8

MOBILE CLEANING EQUIPMENT FOR RECREATION FACILITIES

by

Ted L. Pickett

U. S. Department of Agriculture, Forest Service
Equipment Development Center
San Dimas, California

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ABSTRACT

Mobile equipment for cleaning such facilities as comfort stations, tables, stoves, and fireplaces in Forest Service recreation sites has been developed by the San Dimas Equipment Development Center. Through field testing, the equipment has been proven to be effective in areas where the facilities are compactly arranged and subjected to much usage. The equipment can improve the quality and reduce the man-hour expenditure of facilities cleaning, as well as make the work more acceptable to cleaning crews.

The vehicle can also serve effectively for other maintenance tasks since it has auxiliary electrical power and an optional dump bed.

* * *

A report on ED&T project #1953 - Recreation Facilities Cleanup Vehicle - sponsored by the Division of Recreation Management. The advance report "Recreation Facilities Cleanup Vehicle", issued by SDEDC in November 1970, was a preliminary to which this report is the complete, final version.

INTRODUCTION

Until the last 10-15 years, the facilities (such as comfort stations, tables, stoves, and fireplaces) in small, dispersed recreation sites were used only moderately by the public. The facilities could thus be cleaned easily and economically by manual methods - mops and buckets, scrub brushes, and brooms.

Today, an increasing number of Forest Service recreation sites either are larger than before, or are becoming parts of large complexes. Recreation facilities are being used more by the public. Advances in the standard of living prompt the public to be more discerning, to expect a higher standard of cleanliness. Part of this expectation is that a better cleaning job be done in Forest Service facilities. But, it is increasingly difficult to hire and retain personnel who will clean comfort stations and tables by manual methods. Previously appropriate cleaning methods and equipment are thus outdated and impractical on a cost basis.

Commercial janitorial services are now using specialized cleaning equipment and supplies. Some of these products and techniques can be applied to cleaning recreation site facilities. Mechanization and better methods can reduce costs by reducing manpower requirements (frequently the greatest expense in doing a job) improve the quality and quantity of work, and should also make the job more acceptable to the employee.

DEVELOPMENT

The development of the mobile cleaning equipment progressed through several distinct stages. First, available cleaning equipment and methods were studied, with the most applicable being selected for later trial use. Those selected were then used to establish guidelines for a test model vehicle. This equipment was then assembled into a system, and the system was evaluated during limited trial use. Observations made during the evaluation of the test model made it possible to establish firm criteria for the design of a prototype mobile unit.

INITIAL CONSIDERATIONS

The main task for the proposed mobile cleaning equipment was cleaning facilities of large campgrounds and large complexes of sites. It was necessary to select components that would best accomplish this task. The first component was the high-pressure washer. The high-pressure washer is being used extensively in coin-operated car washes, by sign maintenance companies, and for many other cleaning applications. Such a unit appeared to be desirable for use with the proposed unit.

To clean recreation site facilities, capability of washing with detergent solution, followed by a clean water rinse, also appeared desirable. Complete control of the washer at the nozzle is important, since much time could be wasted in returning from the work to the equipment in order to change from washing to rinsing operations.

Many modern janitorial services have replaced mops with fast, portable, and efficient wet-pickup vacuum cleaners. These cleaners lift dirty waste water and debris from floors after washing is completed, removing excess water much faster than mops and leaving a drier surface.

The final step was to select the vehicle to be used as a carrier for the cleaning equipment. As stated previously, the main problem was that of cleaning facilities in large campgrounds or large complexes of sites. For this application, a vehicle could be committed to the cleanup work for the entire recreation season. But parking such a vehicle in a campground could be a problem, since campgrounds are designed to limit parking. Using a conventional truck could cause parking problems and would often necessitate long, time-consuming hose lays to make use of the cleaning equipment.

A small, compact vehicle, capable of traveling between campground barriers and traversing pathways, can eliminate the parking problem and significantly reduce the length of hose lays. Adequate maneuverability for traversing pathways should also provide superior performance on crowded recreation site roads, and probably reduce time lost while waiting for visitors to enter or leave family units. Based on payload capability, horsepower, optional equipment, availability, and design, a three-wheel Cushman Haulster was selected to carry the assembled equipment. The specifications for the Haulster are contained in Appendix II.

These components furnished a nucleus around which a test model cleanup unit could be developed. Considered functionally, the equipment had two principal design

features. First, it introduced highly mechanized cleaning methods to remote areas, providing pressure washing and rinsing of facilities combined with vacuum pickup of waste water, excess detergent solution, dirt, and debris. Second, because the cleaning equipment was mounted on a small, highly maneuverable vehicle, it could be conveyed close to the work.

TEST MODEL

The selected cleaning equipment was placed in the bed of the Cushman vehicle, along with necessary support equipment. A portable engine-driven generator supplied power for the wet-vacuum cleaner and washer. Two 23-gallon metal drums were used as supply tanks for water and detergent solution for the washer. A garden hose reel was used to store the washer hose, and the wet-vacuum hose was coiled around the drums. Figure 1 shows the configuration of the test model.

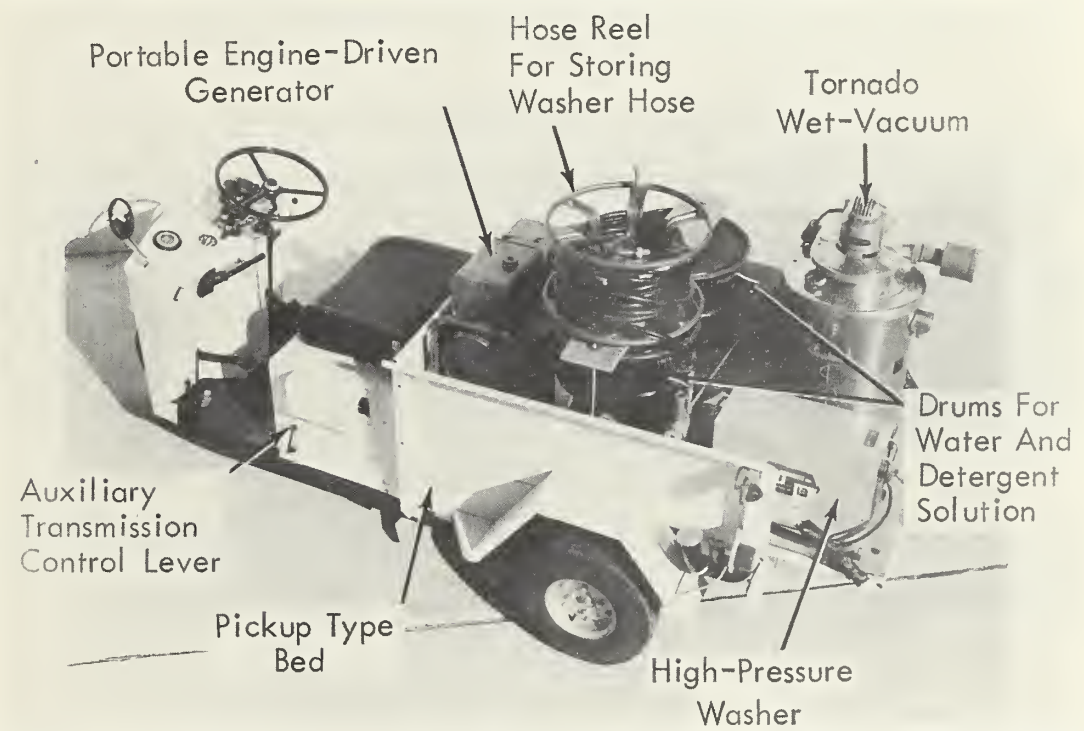


Figure 1. Mobile Cleaning Equipment for Recreation Facilities - Test Model

The test model verified the practicability of the mobile cleaning concept when it was used to clean campground improvements on the Mt. Baldy Ranger District of the Angeles National Forest.

PROTOTYPE DESIGN

The design of the prototype unit is based on the following criteria specified in the ED&T 1953 Project Proposal dated January 19, 1968:

"The basic vehicle should be capable of climbing, stopping, and starting on a 20% grade fully loaded. It should be capable of 2 mph speeds on 5-foot-wide pathways, and 40 mph on paved secondary highways. A power-take-off generator or alternator should provide sufficient power for all integral equipment, plus operation of hand portable power tools such as saws, sanders, grinders, etc. Three tanks should provide storage for approximately 15 gallons of chemical concentrate, 30 gallons of fresh water, and 15 gallons of waste water. An electrically driven pressure-washer should be capable of delivering about 500 psi at 3 gpm with all pump controls at the nozzle. A live reel with 35 feet of high pressure-control cable hose should be provided for the pressure-washer. A wet-vacuum should be capable of removing all excess chemicals and water from facilities which have been cleaned. A reel or hose basket should be able to hold 30 feet of $1\frac{1}{2}$-in.-vacuum hose."

Power Supply

The high-pressure washer and wet-vacuum cleaner used on the test model were retained on the prototype unit, which made it possible to arrive at firm electrical criteria for a power supply. A study showed that the power supply must produce 2400 volt amperes (VA) at 115 volts, 55 to 60 hertz power and be capable of 7000 VA surge.

An air-cooled alternator was selected. This unit is air-cooled and is rated for 3800 watts continuous load, 7000 watts surge.

Power Supply Drive Line

The alternator is driven by the Cushman vehicle engine through a power-take-off drive. To drive the alternator at the proper speed, it was necessary to add a speed changing gear box and a belt drive.

Electrical System

Because of the possibility of splash on the undercarriage of the vehicle and the possibility of the vehicle being in the open on rainy days, all wire, cable, conduit, and other electrical components are water-resistant.

The electrical output of the alternator is split into three circuits, each protected against overload by a 15-amp pull-to-reset circuit breaker. One circuit is routed to power the washer, another to power the wet-vacuum cleaner, and the third to supply power to the extension cord reel.

Slip-on Unit

The slip-on unit is essentially a single package containing a high-pressure washer, the wet-vacuum cleaner, tanks, tool and supply cabinet, and hose reels. The tanks

are fabricated from stainless steel to insure a long life when corrosive detergent chemicals are used.

The wet-vacuum cleaner mounts directly on the waste water tank. This tank will accept about 15 gallons. It is designed to be emptied through a $1\frac{1}{2}$-inch gate valve at the rear of the tank, which is located at the rear of the Cushman's bed. Adequate space for 30 feet of vacuum hose is provided alongside the wet-vacuum cleaner tank. Space for storing the wet-vacuum cleaner floor tool is provided between the slip-on unit and the side of the pickup's body.

A single tank with two separate compartments is located at the front of the bed to locate the center of gravity as near as possible to the center of the vehicle. One compartment of this tank is capable of holding 30 gallons of clear water for rinsing, and the other can hold about 15 gallons of detergent solution. A small, spring-retractable hose reel has been mounted on the top of these tanks. It contains 25 feet of $\frac{1}{2}$-inch garden hose for filling the tanks from any faucet or hydrant with garden hose threads.

The high-pressure washer, containing an electric-motor-driven piston pump, is mounted at the rear of the slip-on unit on the side opposite from the wet-vacuum cleaner. The suction hoses for the washer are connected directly to the bottom of the water and detergent tanks.

The space in the center of the slip-on unit is used as a tool and supply cabinet. This space is covered to protect toilet paper, paper towels, etc., from rain damage. The spring-retractable hose reel for the pressure washer is mounted on the left of the top of this cabinet. The remainder of the top of the cabinet is hinged for easy access. The hose reel is connected to the discharge of the high-pressure washer through a swivel joint rated for 1000 psi. It is connected electrically to the washer through a five-conductor slip-ring assembly.

Figure 2 shows the prototype and identifies the various components.

TESTING

The mobile equipment unit was thoroughly tested over a period of about 5 months (from May to September, 1969). Shakedown tests were first conducted on the Arrowhead District of the San Bernardino National Forest. The first week of the training period was used to train the operator and demonstrate the vehicle to Forest and Regional personnel. This procedure was followed at all three sites.

The unit was modified to correct problems found during the shakedown tests, then was subjected to about 3 months of formal tests. The formal tests consisted of operational trial use at selected sites for one month each in the Southwestern Region, the Intermountain Region, and the Pacific Northwest Region. After these formal tests, minor repairs were made on the equipment. It was then put into service on the Angeles National Forest for additional testing of the mechanical components.

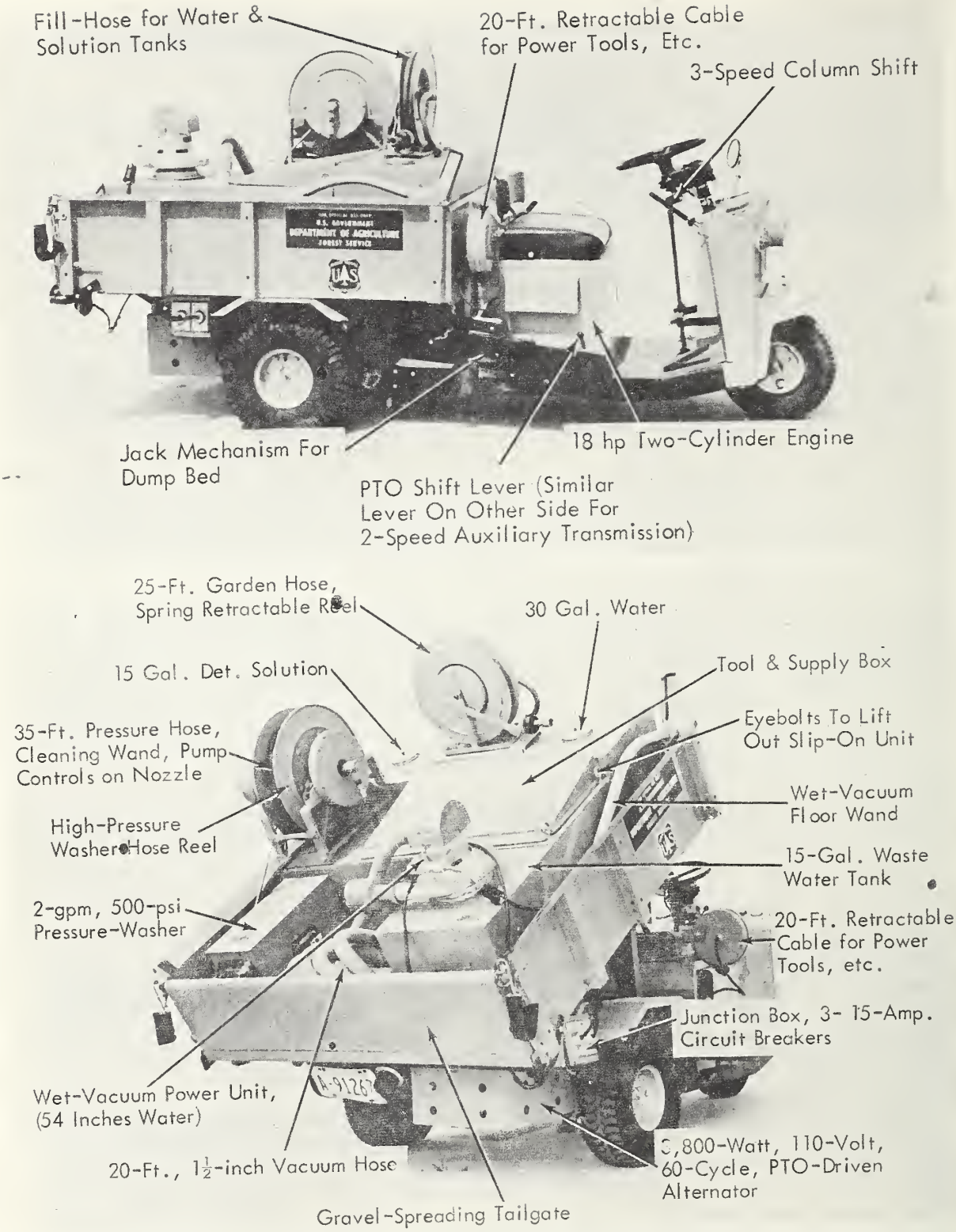


Figure 2. Prototype of Mobile Cleaning Equipment for Recreation Facilities

SHAKEDOWN TESTS

The most critical problem encountered during the shakedown tests was ground clearance of the vehicle itself. To correct this problem, heavy-duty 6.00 x 7.75 tires were installed. They are the largest diameter standard for Cushman vehicles.

Maps showing the sites used in the shakedown tests are contained in Appendix I.

OPERATIONAL TRIAL USE

Site 1

The Sedona Ranger District of the Coconino National Forest in the Southwestern Region was selected for the first operational trial. The complex of twelve small-to-medium size recreation sites scattered along 16 miles of Oak Creek Canyon is one of the areas where the mobile unit was thought to be appropriate. All of the comfort stations have vault toilets, predominantly of wood frame construction. During the first week, conditions were observed that resulted in an appropriate man-hour comparison. Access to many of the comfort stations was inadequate for the Cushman vehicle, with two or three impossible to reach. The problem was the disproportionate amount of time required for traversing rough terrain and following narrow winding trails to reach comfort stations that were, at most, about 200 feet from the nearest roadway.

For some time, the maintenance personnel have been using a pressure-washing system employing a pickup truck with a tank, high-pressure pump, about 200 feet of hose, and miscellaneous cleaning supplies. Since the intent of the study was to compare manual cleaning methods with those of the mobile equipment, the results at Oak Creek were not too valuable, but the vehicle functioned well throughout the 1-month testing period.

Site 2

The Flaming Gorge National Recreation Area in the Intermountain Region was selected as the second test site. This area has several large campgrounds and complexes of recreation sites. At least two individual campgrounds are sufficiently large to provide adequate work for the mobile cleaning equipment. Lucerne Valley was selected as the particular site for testing. There is a modern 180-family unit campground within 1 mile of a marina with extensive improvements, along with other nearby minor facilities.

The comfort stations at this site are predominantly concrete-block structures with flush toilets, lavatories, and utility rooms. Access to the comfort stations for the mobile equipment was excellent in almost every case, and most of the routes were paved.

This site provides a desirable contrast with Site 1 in terms of manual versus vehicle cleaning methods. The comfort stations are all in a relatively small area and access is easy, thus reducing travel time and increasing the actual time available for cleaning.

Site 3

The Cle Elum Ranger District of the Wenatchee National Forest in the Pacific Northwest Region was selected as the third test site. The Kachess Lake Campground complex on this district is a collection of medium and small campgrounds. The largest campground, a modern 85-family-unit site, supplied a good basic workload for the mobile cleaning equipment, and other small sites near this one provided sufficient facilities to test its capabilities.

The equipment was used for cleaning both modern flush-toilet facilities, which were easily accessible, and scattered vault toilets, which were not easily accessible.

TEST RESULTS

OBTAINING DATA

At each site, the operator of the mobile unit was requested to maintain daily log sheets listing the number of comfort stations, fixtures, tables, and other cleaning chores. Any other maintenance work done was included along with the time required to do the jobs and the hourly rate of the operator. The daily costs of cleaning supplies, gasoline, oil, mileage, engine hours, and power-take-off hours were itemized along with information designed to determine if existing tank sizes are adequate. Space for writing general remarks and listing other equipment used was provided on the log sheets.

The operator, usually a temporary employee assigned to the maintenance crew, was requested to maintain similar log sheets for one other month during the summer. This procedure was devised to obtain data for their normal operations so that comparisons could be made.

At the end of the 1-month operational trial use at each site, the operator and his supervisor filled out an appraisal form. The form asked many specific questions regarding performance of the equipment and its features. The form also provided space for remarks covering the operator's observations and suggestions for improvements.

The table on page 10 is a summary of the average times expended for each cleaning job, broken down to reflect each site separately. Forest personnel can compare these times with those required in their own forests for similar work.

The data for Oak Creek show that their normal cleanup methods required slightly less time than that required for using the mobile cleaning equipment. Access for the cleanup vehicle was difficult and their "normal" cleaning methods were not completely manual. The difference between the time per fixture at Oak Creek (with the Cushman) and that at Kachess Lake for vault comfort stations is significant. The time consumed at Oak Creek was four times as long as at Kachess Lake, while the cleaning job was similar and the cleaning quality was almost identical. The only difference is the site, and the major cause for the difference in time must lie in travel time between comfort stations. Certainly some of the travel time between stations

Average times expended for each cleaning job - by sites.

SITE	MONTH	TIME PER COMFORT STATION IN MINUTES	TIME PER FIXTURE IN MINUTES
No. 2 Flaming Gorge w/mobile equipment	July	29.00 minutes (flush station)	5.31 minutes
No. 2 Flaming Gorge w/manual cleaning	August	57.38 minutes (flush station)	10.67 minutes
No. 1 Oak Creek w/mobile equipment	June	37.99 minutes (vault station)	15.88 minutes
No. 1 Oak Creek w/pressure cleaning equipment	July	29.07 minutes (vault station)	13.48 minutes
No. 3 Kachess Lake w/mobile equipment	August	8.70 minutes (flush station) 3.87 minutes (vault station) 7.02 average	2.91 minutes 3.87 minutes 3.05 average
No. 3 Kachess Lake w/manual cleaning	July	6.02 minutes	3.15 minutes

in Oak Creek was spent traveling between campgrounds, but on-site observations indicate that most of the time differences between Kachess Lake and Oak Creek were caused by the access difficulty at Oak Creek.

FINDINGS AND SUGGESTIONS

The appraisal forms produced many informative comments. Some of the suggestions could not economically be incorporated in the final design, but a serious attempt was made to include suggestions frequently aired. There is a considerable quantity of data and comments on the appraisals, along with excellent memos from two of the sites. These findings are summarized in the following paragraphs.

Overall comments from the field indicate that on a time basis the equipment does an excellent cleaning job, particularly in areas with extensive, compact facilities for 60 family units or more. Manual cleaning can produce better results, but only if much more time is spent by conscientious workers. Field personnel unanimously felt that the mobile cleaning equipment made the job more acceptable.

The equipment shows its best potential for cleaning flush and vault toilets, and interiors in comfort stations. Other jobs it performs well are cleaning tables, louvers, vent screens, building exteriors, signs, and automotive vehicles. It performs less well, but has value with the proper detergents, at cleaning fireplaces, garbage cans, and vehicle engines.

The field accepted with minor qualifications, the high-pressure washer as being a valuable cleaning tool.

The water and detergent tanks were reported to be sized correctly, and the method of filling them was satisfactory. The waste-water tank for the wet-vacuum cleaner was reported to have three problem areas. It was too small, and draining and cleaning were difficult. Better access to the interior of the tank was recommended, so that the combination of a larger drain valve and good access from the top would make removing large debris easier.

The wet-vacuum cleaner met with enthusiastic reception as a cleaning tool. Its performance was good, and the hose length of 20 feet was adequate for almost every task.

The auxiliary electrical power extension cable was used at every site. Primarily, it was used for drills and other power tools, but on one occasion it was used to power a movie projector. Although the cord reel was an inexpensive unit, it was not included in the final design. The reel was not used frequently, and its rewind mechanism did not function perfectly. The only time it was used heavily was at Flaming Gorge where the maintenance crew was installing ticket boxes at each parking space of a 180-unit campground. They reported that the auxiliary power was used to drive a drill and screwdriver attachment resulting in a savings of two-thirds the time required to do the job by hand.

FINAL DESIGN

After the cost comparison study was completed and the comments of field personnel were reviewed, the final design was begun. The field suggestions regarding the wet-vacuum cleaner tank made it desirable to redesign this area of the unit. Other desirable changes included noise reduction in the alternator drive line, incorporation of a redesigned high-pressure washer (the older model is no longer on the market), and a search for less expensive hose reels.

Redesigning the wet-vacuum cleaner tank to increase its capacity and improve the method of draining was one of the suggestions most frequently proposed by the field. This was not feasible without redesigning the entire system. A larger tank and components would be too heavy for the vehicle. The solution was to design a unitized structure. That is, the detergent and water tank, tool and supply box, wet-vacuum cleaner tank, etc., mount to and support each other.

In the final design, the wet-vacuum cleaner tank has a capacity of 20 gallons, It can be drained through a 3-inch plastic slide valve. The detergent solution tank holds about 15 gallons; the rinse water tank can carry about 30 gallons. The volume of the tool and supply box in its final configuration is about $8\frac{1}{2}$ cubic feet.

The major cause of noise in the alternator drive line was the spur gears used in the speed-increaser gear train. Extensive consultations with the manufacturer produced a relatively inexpensive solution. They have agreed to fabricate identical gear boxes with the same power rating and speed ratio using helical gears for $38 additional cost, if ten or more units are purchased on a single order. Helical gears run more quietly than spur gears with only 2 percent loss in efficiency.

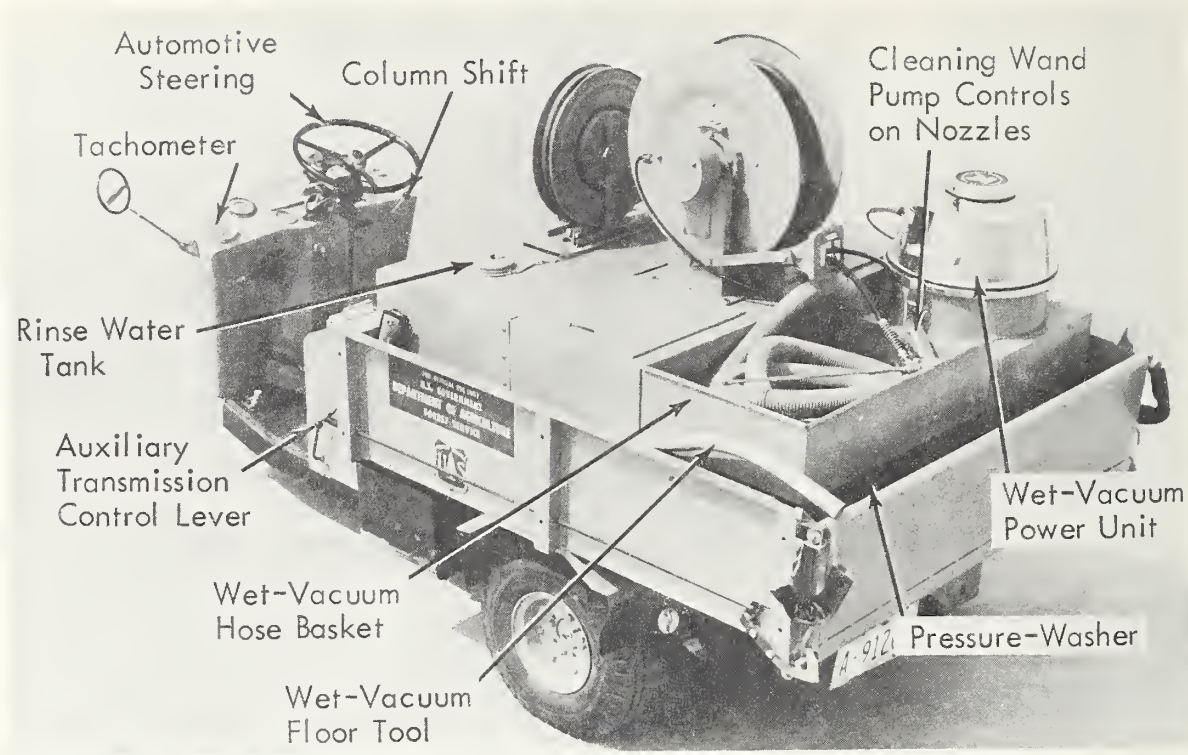
The control cable, high-pressure hose reel used on the prototype was a specially fabricated item; as such it was expensive. Discussions with several manufacturers resulted in the decision of one to market a standard reel that would meet our requirements. As a standard production item, the spring-retractable hose reel will be about $50 less than the original reel. The prototype design for the alternator and its drive line is satisfactory for the final design, since power requirements for the final wet-vacuum and washer are virtually identical to those used on the prototype.

CONCLUSIONS

1. The mobile cleaning equipment can substantially reduce the labor cost of campground cleanup chores.

2. Its use can improve and standardize the quality of facilities cleaning.

3. The equipment shows its best potential for cleaning flush and vault toilets, and interiors in comfort stations. Other jobs it performs well are cleaning tables, louvers, vent screens, building exteriors, signs, and vehicles. With the proper detergents, it has value in cleaning fireplaces, garbage cans, and vehicle engines.



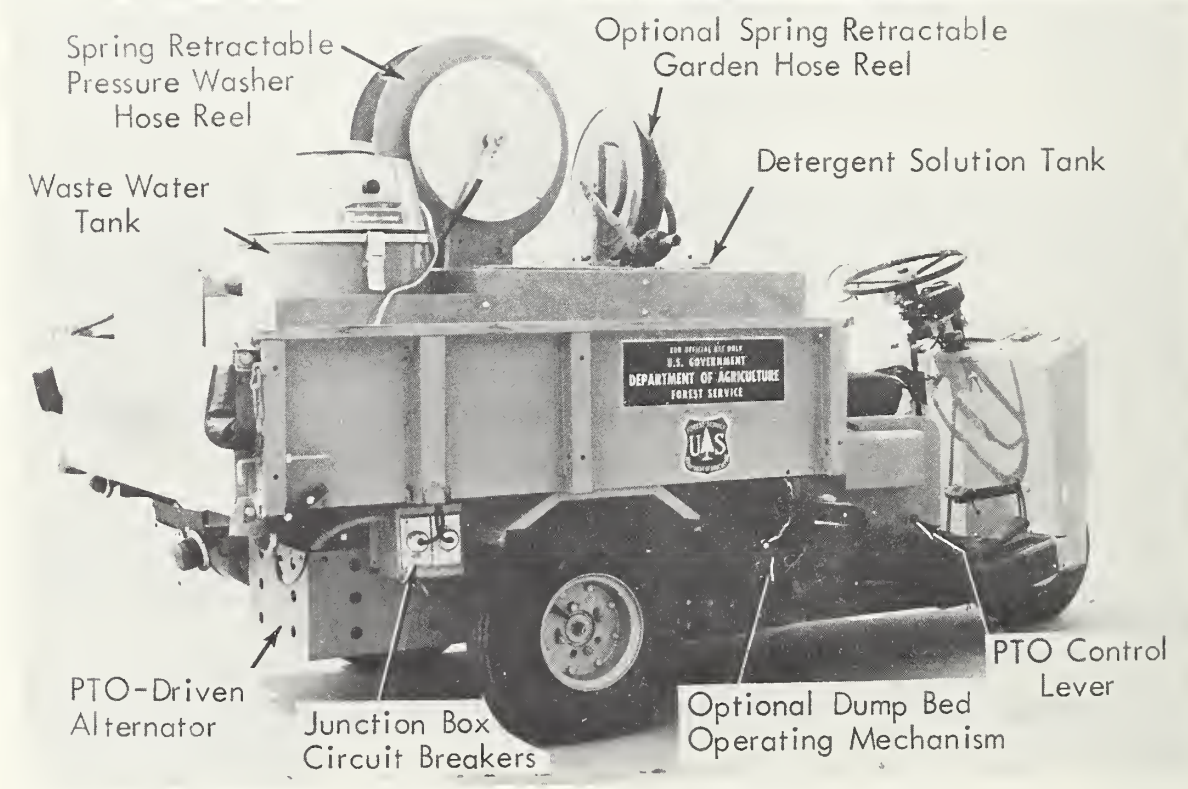


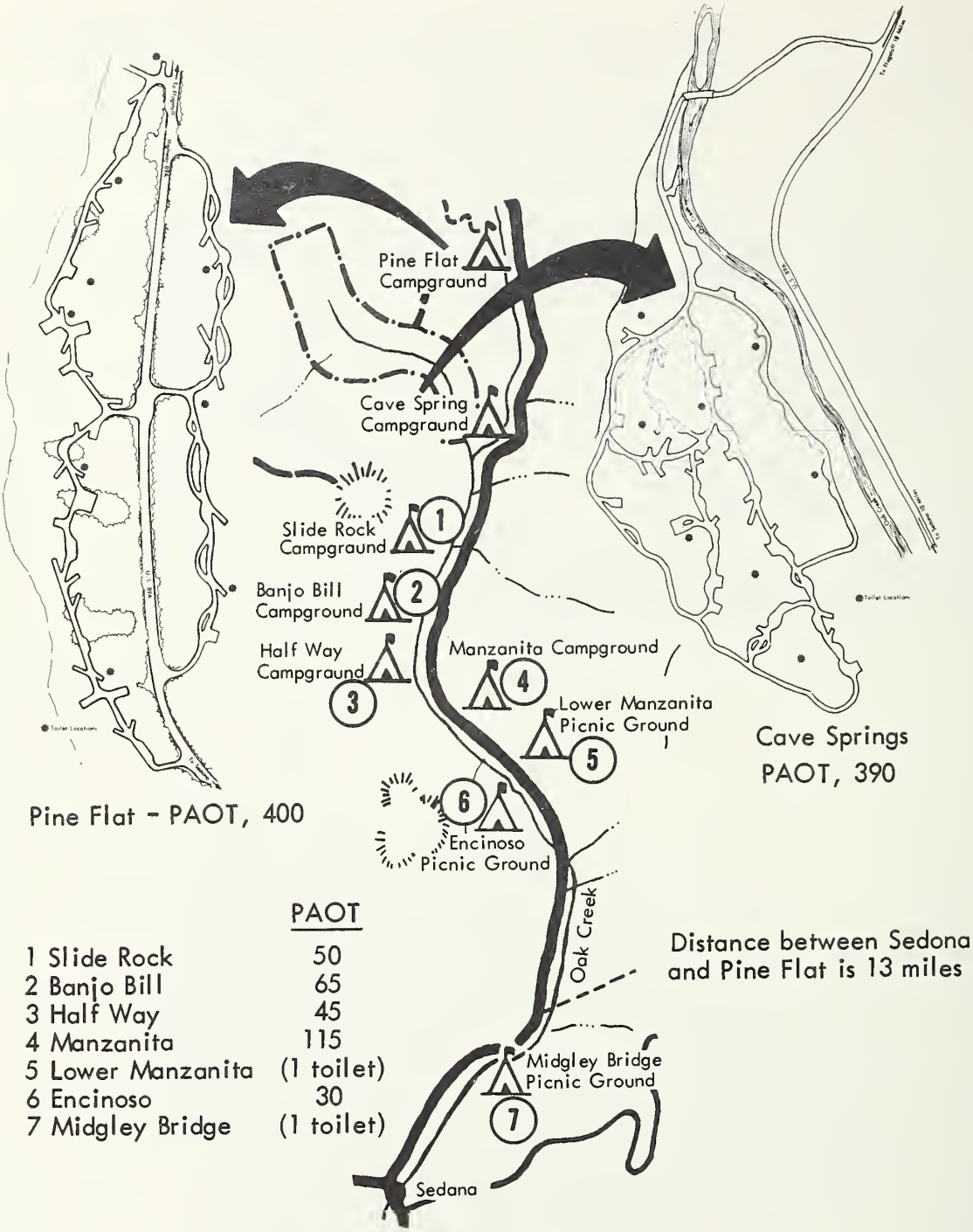
Figure 3. Final Configuration of the Mobile Cleaning Equipment for Recreation Facilities

4. It is most effective in areas where the facilities are compactly arranged and subjected to much usage. Facilities for 60-family units or more, providing they are not greatly dispersed, can provide a cost-effective area for the vehicle if access to comfort stations is good.

5. Time expended in travel between cleaning chores can be by far the most costly factor in cleaning recreation facilities.

6. Mechanizing the cleanup of facilities can make the job more acceptable to cleaning crews, yield higher quality work, and reduce the turnover rate for, and training of, new or replacement crew members.

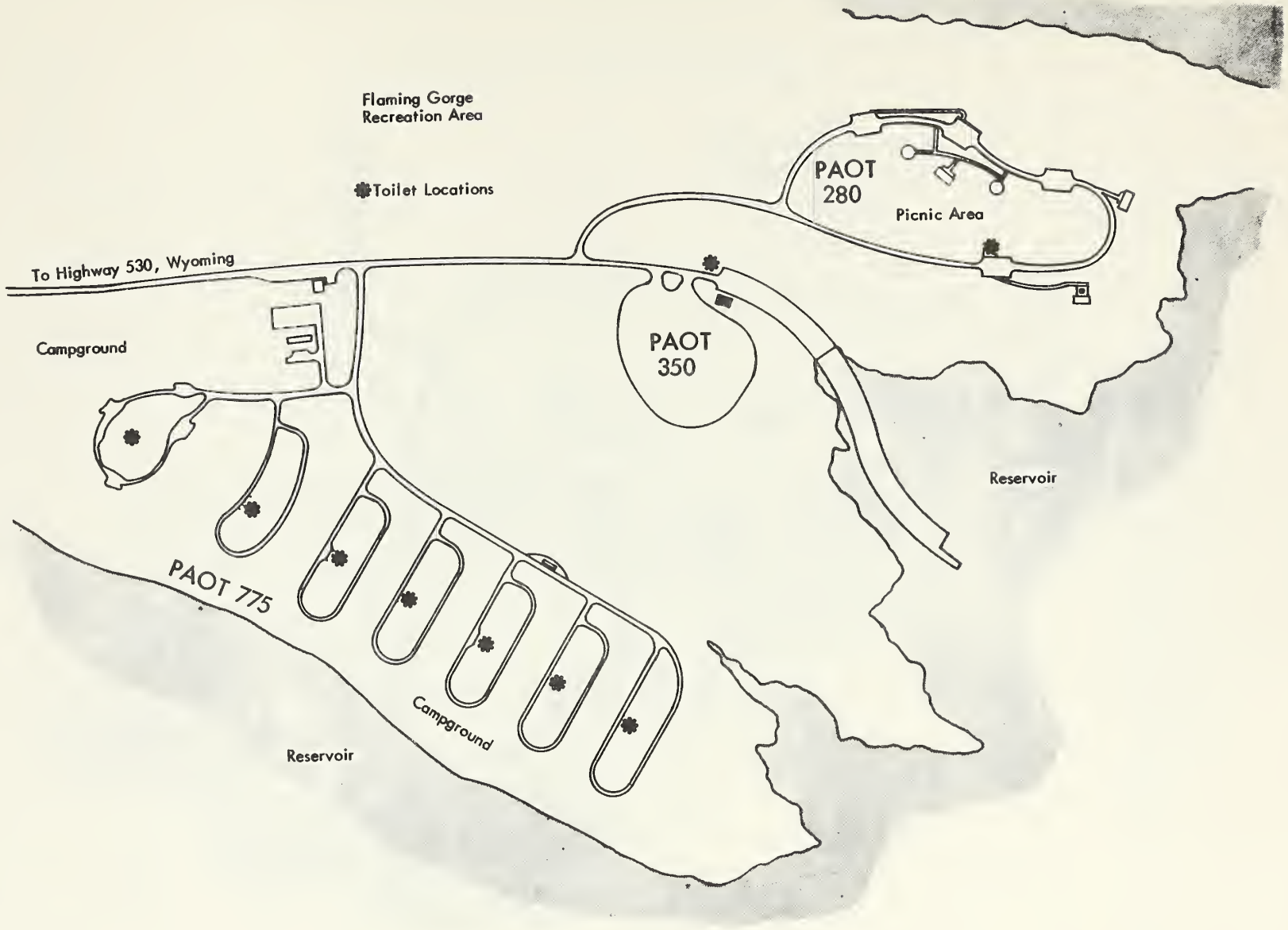
7. Auxiliary electrical power on the cleanup vehicle can be an extremely useful accessory.



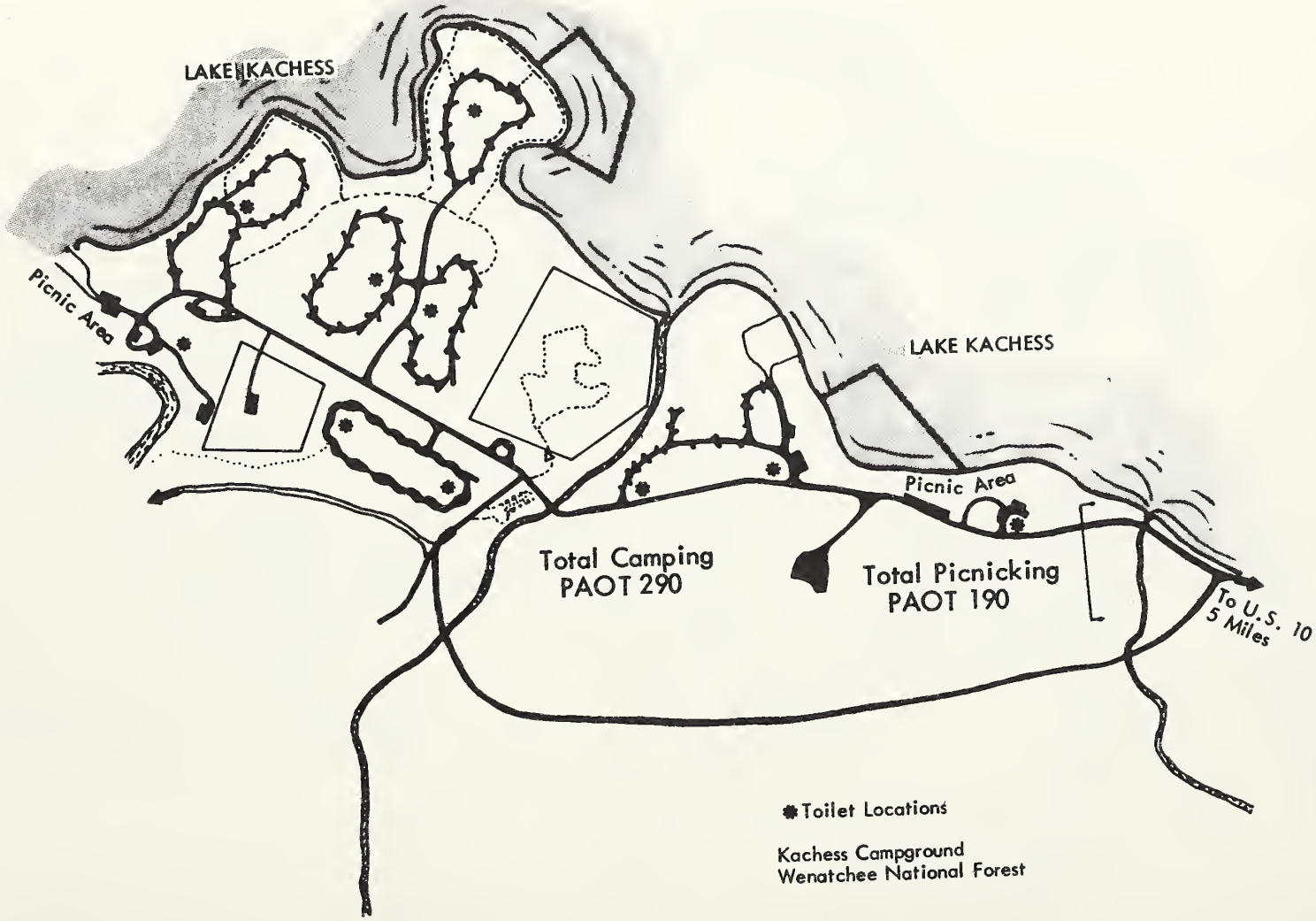
	PAOT
1 Slide Rock	50
2 Banjo Bill	65
3 Half Way	45
4 Manzanita	115
5 Lower Manzanita	(1 toilet)
6 Encinoso	30
7 Midgley Bridge	(1 toilet)

Site 1 Map. Layout of the Facilities.

* Persons at one time.



Site 2 Map. Layout of the Facilities.



Site 3 Map. Layout of the Facilities.

APPENDIX II

Cushman Haulster (Special order on a stationary wide bed chassis.)

Dimensions: Length - 115 inches, width - 58 inches, wheelbase - 72 inches, wheel tread - 48 inches, interior bed length - 57 inches, interior bed width - 53 inches, interior bed depth - 12 inches.

Weights: Base vehicle empty weight (approximately) - 1100 lbs., approximate gross vehicle weight (GVW) - 2800 lbs., weight with slip-on (tanks empty) - 1800 lbs., weight with slip-on (tanks full) - 2200 lbs.

Steering: Automative, turning circle - 15 feet.

Engine: 18 hp, OMC 2-cylinder, air cooled, 4-cycle, 43.3 cu. in.

Transmission: 3-speed column shift plus 2-speed auxiliary, total 6-speeds forward, 2 reverse.

Power-Take-Off: Transmission mounted, constant speed governor included.

Rear Axle: 6.5:1.

Rear Suspension: Transverse leaf, coil helpers, shocks, torsion bar stabilizer.

Tires: Rear - 690/600X9, front - 500/570X8.

Gradability: Start and climb (loaded) - up to 30%, sideslope - 20-25%.

Ground Clearance: 5 inches to frame.

Brakes: Hydraulic internal expanding on all 3-wheels.

Electrical: 42-amp alternator, 12-volt battery.

Gauges: Speedometer, tachometer, engine hour-meter, ammeter, fuel.

Options: Mechanical dump bed with gravel spreading tailgate, fiberglass cab, doors, windshield wipers.

Electrical Modification (Permanently mounted to Cushman.)

Alternator: Pincor Model GBRF3800H, 115-130 volts AC, 55-60 Hertz, 3800 watts continuous, 7000 watts surge, 3600 alternator RPM at 2600 engine RPM.

Protection: Ventilated 16-gauge steel cover.

Drive: Power-take-off driveshaft to industrial helical gear speed changer to 3 matched 3V250 belts to alternator.

Circuits: 2 - 15 amp breakers, all wiring and boxes of dripproof construction.

Slip-on (Secured by 4 bolts through tool box to Cushman bed.)

Dimensions: Length - 55 inches, width - 47 inches, height - 43 inches.

Pressure-washer: L & A Products Model 802M-35; 3/4 hp copacitor start motor, 13 amp; belt-driven Hypro positive displacement pump, 2.3 gallon-per-minute, 500 pounds-per-square-inch pressure; electric solenoid valves; 3-mode dial control on cleaning wand (off-mix-rinse); remote control circuit 28 volts AC, 1-amp; 35 feet 5/16-inch pressure hose and remote control cable encased in twin sleeve vinyl scuff jacket; straight-stream, 15° fan and 40° fan nozzle tips.

Hose Reel: Coxwell special model; spring retroctable; 5-conductor, 1-amp electrical left hub; 1000 psi liquid right hub.

Supply Tanks: Stainless steel, 15-gallon detergent, 30-gallon rinse, in-line filters.

Wet-Vacuum: Kent Turbovac Model 85-5000, 92 inches static vacuum, 2 hp input universal motor, 20-gallon stainless steel waste water tank, automatic floot shutoff, 3-inch slide dump valve, 20 feet 1-1/2-inch vacuum hose, hose basket, 5-foot floor wand, 14-inch squeegee flaor tool.

Tool and Supply Box: 8.5 cubic feet.

Option: Spring retractable reel with 25 feet 1/2-inch hose for filling detergent and rinse tanks.